CHAPTER 6

PARALLEL PROJECTIONS

Overview

Introduction   All objects that you as a Illustrator Draftsman draw are three dimensional. The problem facing you is presenting three dimensions (length, width, and depth) on a two-dimensional plane, which is your drawing surface. In the last chapter we discussed depicting length, width, and depth pictorially in perspective projections. In this chapter, three-dimensional objects drawn on two-dimensional surfaces in a way that exposes and explains each surface of the object is called parallel projections. Parallel projections are used in technical drawing and drafting applications.

Objectives   The material in this chapter enables you to do the following:

- Define and identify parallel projections.

- Recognize the characteristics of oblique parallel projections.

- Identify the primary difference between oblique cavalier and cabinet projections.

- Recognize the characteristics of orthographic parallel projections.

- Name the three types of axonometric projections.

- Identify predominant features in isometric projections.

- Recognize the differences between first- and third-angle projections.

Overview, Continued

Acronyms   The following table contains a list of acronyms that you must know to understand the material in this chapter:

Acronym	Meaning
CL	Centerline
PP	Plane of Projection
SP	Station Point
VP	Vanishing Point

In this chapter   This chapter covers the following topics:
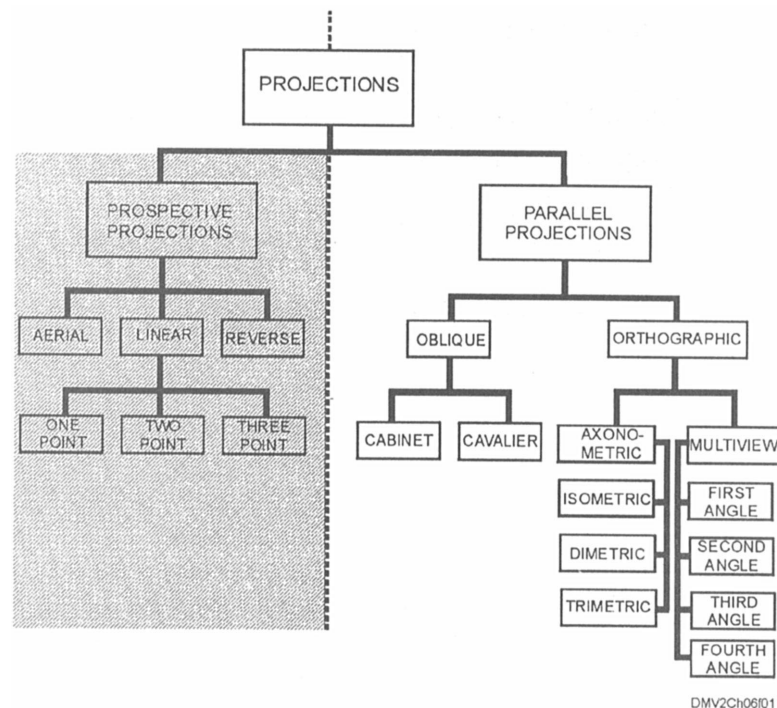
Parallel Projections

Introduction   A view of an object is known technically as a projection.   Projection is done, in theory, by extending lines of sight called projectors or visual rays from the eye of the observer or station point (SP) through lines and points on the object to the plane of projection (PP).   Projectors that appear to converge at a vanishing point (VP) are called *perspective projections* and are used in technical sketching. Projectors that remain parallel to the object and perpendicular to the picture plane are called *parallel projections* and are used in technical drawing and drafting applications.

Parallel projections   Parallel projections are projections where visual rays remain parallel to the object. Regardless of the relative positions of the object, the plane of projection, and the distance from the observer, parallel projections of objects have the same dimensions as the objects. Parallel projections may be further classified into oblique and orthographic projections.

Figure 6-1 shows the classification of major projections.

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Figure 6-1.—Projections.

Oblique Projections

Introduction   An oblique projection is one of two major classifications of parallel projection.

Oblique projections   An oblique projection is the projection of an object in which the projectors are other than perpendicular to the plane of projection. An oblique projection shows front and top surfaces that include the three dimensions of height, width, and depth. The front or principal surface of an object (the surface toward the plane of projection) is parallel to the plane of projection. Surfaces oblique to the plane of projection are not shown in their true size. Oblique projections are superior to orthographic projections in pictorially representing objects.

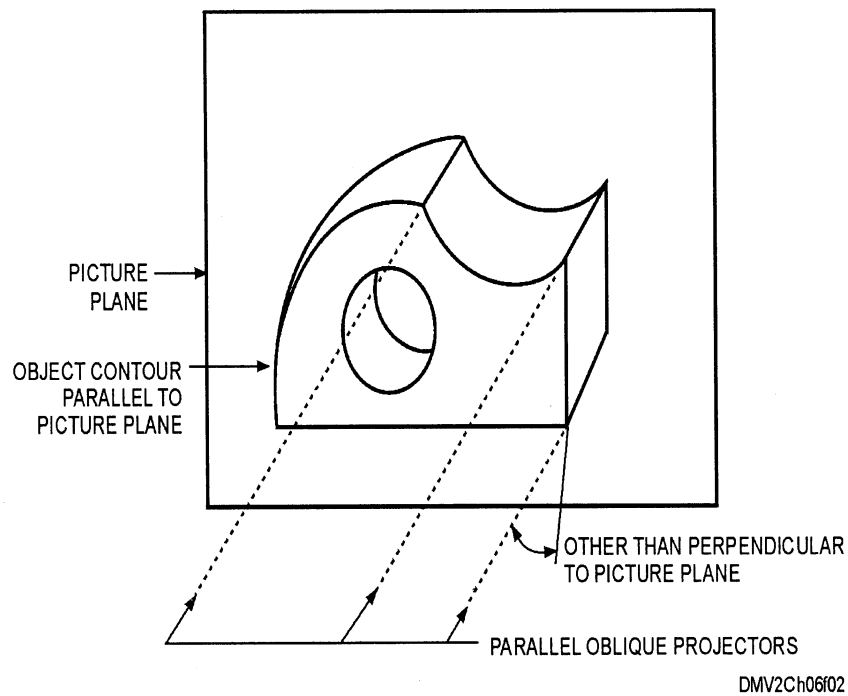Figure 6-2 illustrates the angle of the projectors in oblique projection.

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Figure 6-2.—Oblique projection.

Oblique Projections, Continued

Selecting a surface

Only one surface of the object can be parallel to the picture plane and represented in its true size and shape.   Place the surface with the irregular outline or contour (curved or circular features) parallel to the picture plane or place the longest dimension of the object parallel to the picture plane. If the object is such that the surface with the longest dimension conflicts with the irregular surface, always place the irregular surface parallel to the picture plane.   This procedure minimizes distortion in the projected image.

Direction of the projectors and line length

Line lengths projected in oblique projection are determined by the angle of the projectors to the plane of projection. Projectors that angle 45° to the plane of projection project lines perpendicular to the plane of projection in true length. When the angle of the projectors is greater, the line projected is shorter. When the angle of the projectors is smaller, the projected line is longer. Theoretically, any line perpendicular to the plane of projection could project any length from zero to infinity. Any line parallel 'to the plane of projection will project in true size.

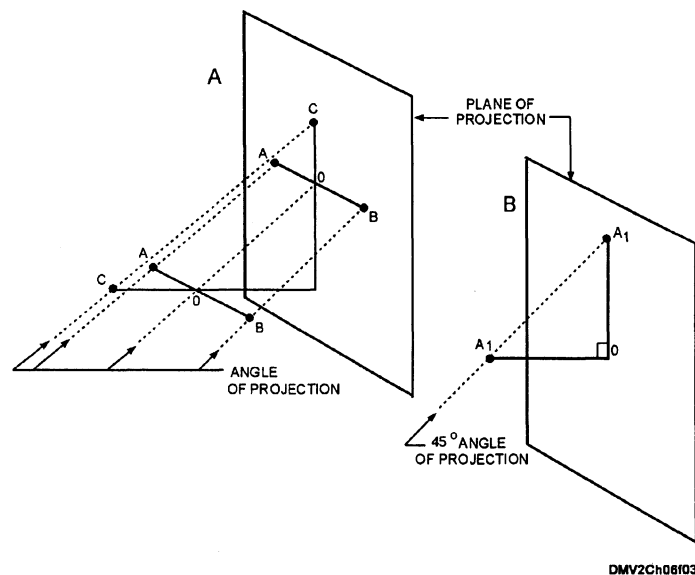Figure 6-3 shows line length relative to the angle of the projectors.

Figure 6-3.—Line length: A. Lines parallel, and B. Lines perpendicular to the plane of projection.

Oblique Projections, Continued

Receding lines   Lines perpendicular to the plane of projection appear in oblique projection drawings as parallel inclined lines. These lines appear to recede but never to converge; hence the name, *receding lines.*

Angles of receding lines   You may draw receding lines at any convenient angle. The angle you select to draw receding lines depends on the shape of the object and the location of any significant surface features. Use a large angle to draw receding lines when you want a better view of the top of an object.   Use a small angle when you want to show features on the side of an object.   Choose angles easily drawn with 45° and 30°/60° triangles.

Length of receding lines   Oblique projections present an unnatural appearance to the eye because the receding lines do not converge into a vanishing point but remain parallel and seem to diverge in the distance. The length of the receding lines contributes to distortion. Receding lines drawn in full scale give the appearance of being too long and raising the back of the object higher than the top or front surface. For this reason, objects with great length should not be drawn in the oblique with the longest dimension perpendicular to the plane of projection. For the object to appear more natural, foreshorten the receding lines. Oblique projections with full scale receding lines are known as *cavalier projections.*   Drawings where the receding lines are foreshortened by half are referred to as *cabinet projections.*

Figure 6-4 illustrates the difference in distortion between a cavalier and cabinet projection.
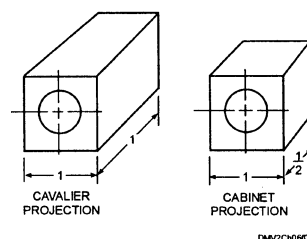

Figure 6-4.—A distorted cavalier projection and foreshortened cabinet projection of a cube.
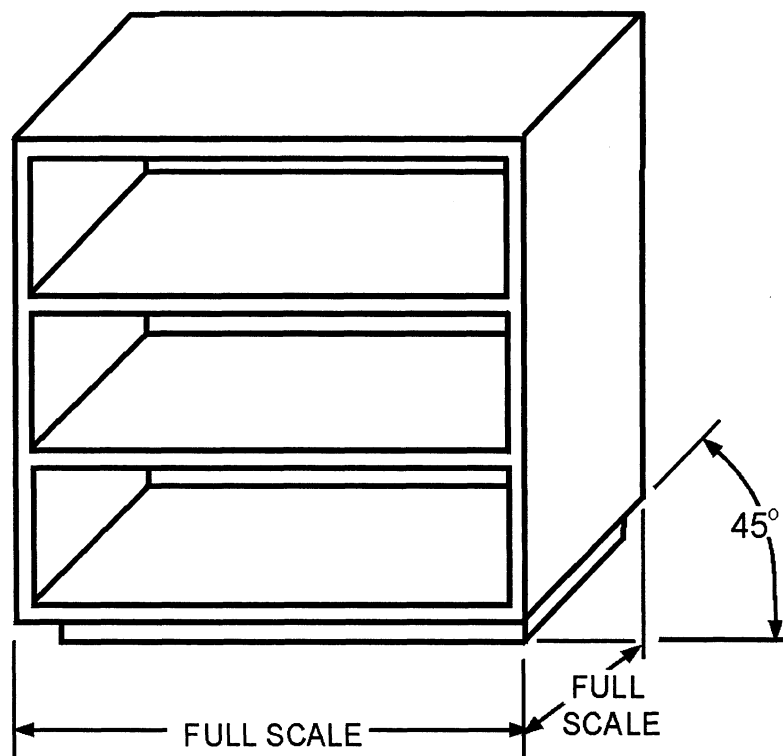
Oblique Projections, Continued

Cavalier projections

Cavalier projections are oblique projections where the front axes are always perpendicular to each other and the receding axis is drawn at any angle other than 90°. When the receding axis is drawn at an angle of 45° with the plane of projection, all edges are projected their true length. For this reason, most cavalier drawings use the 45° angle. Cavalier projections originated in the drawings of medieval fortifications and were made on the horizontal planes of projection. The central portions of these fortifications were higher than the rest and were called cavalier because of their commanding position.

Figure 6-5 shows an oblique projection of a bookshelf drawn in full scale with the receding axis at a 45° angle to the horizontal.
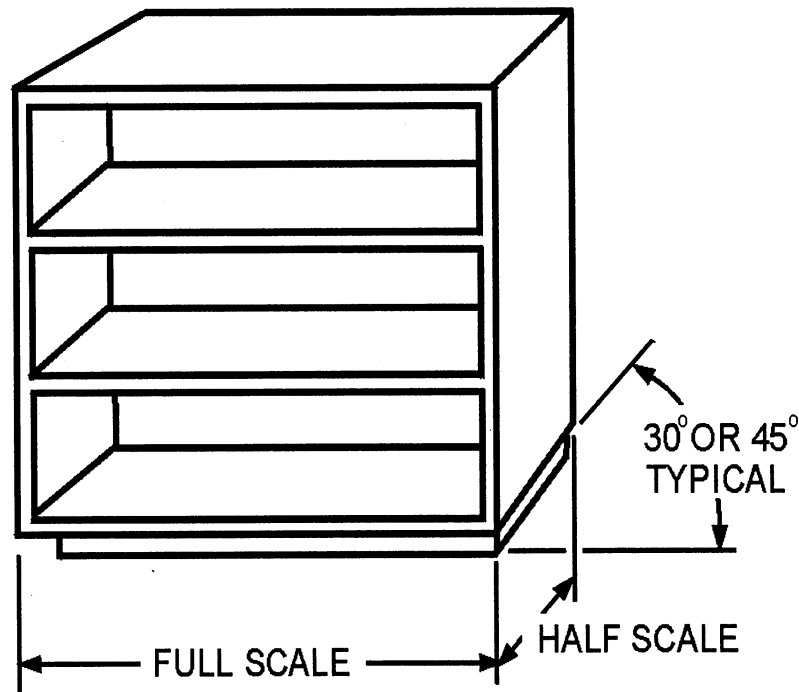

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Figure 6-5.—A cavalier projection.

Oblique Projections, Continued

Cabinet projection

Cabinet projections are oblique projections where the receding axes are drawn at any angle with the horizontal but usually drawn at 30° or 45°. The full scale of the receding axis distorts the projection and requires foreshortening to look more natural. You may use any oblique ratio (two to three or three to four) but a one to two (one half) ratio is more common. When you reduce the scale by half, it is called a *cabinet projection.* The term *cabinet drawing* comes from drawings in the furniture industry.

Figure 6-6 shows a bookcase with the receding axis reduced in scale by half.

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Figure 6-6.—A cabinet projection.

Oblique Projections, Continued

Oblique drawing practices

In general, begin an oblique projection by drawing a centerline (CL) skeleton and building the drawing on these centerlines. Make sure to construct all points of tangency, particularly when you are planning to ink in the drawing.

Circles, arcs, and ellipses

Objects with surfaces parallel to the plane of projection that contain circles, arcs, and ellipses project in true size and shape. Circles not parallel to the plane. of projection project as ellipses. Circles, arcs, and ellipses have no transferable linear measurements and this requires you to inscribe the circle, arc, or ellipse in. an equilateral parallelogram or square. Draw perpendicular bisectors to the four sides of the parallelogram to locate the centers of the circle or arc. This method works best in cavalier drawings because the receding axis is drawn full scale. An alternate method of drawing a circle in an oblique cavalier projection is by the alternate four-center ellipse method.

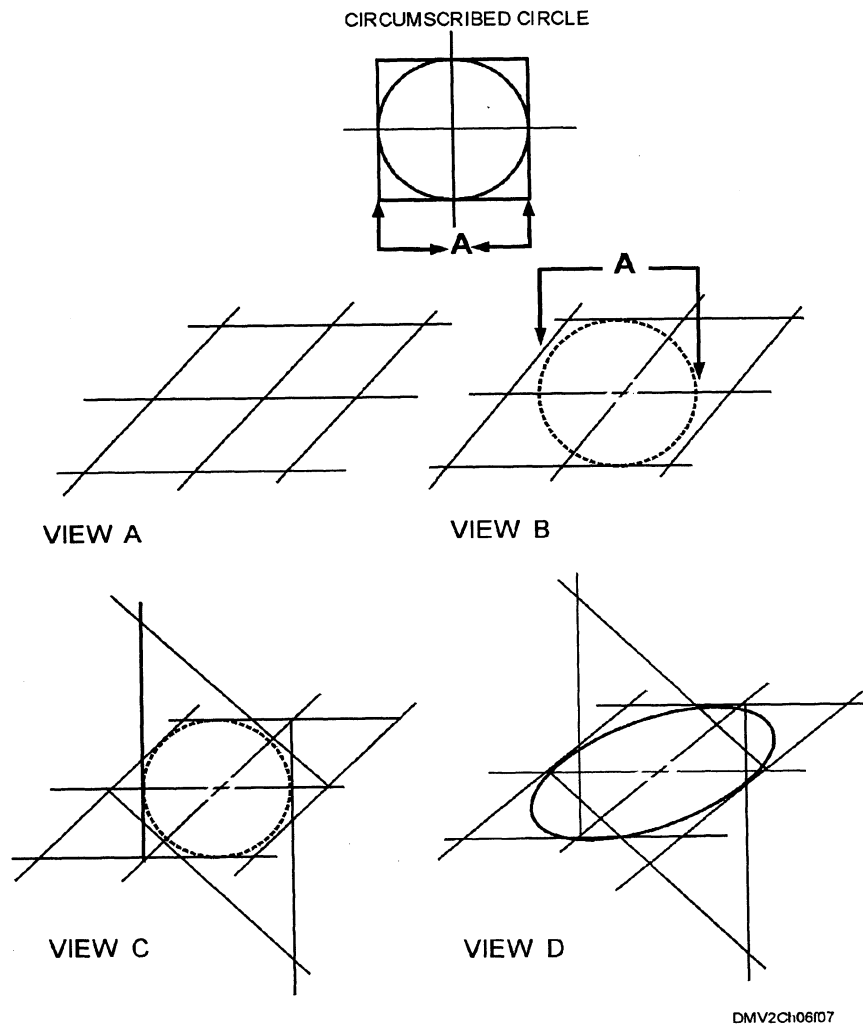To draw a circle in oblique projection by the four-center method, use this table:

Step	Action
1	Draw a vertical and horizontal centerline with the horizontal center line receding from the plane of projection.
2	Construct a circle equal in diameter to the actual circle using as a center the intersection of the vertical and horizontal centerlines.
3	The constructed circle will intersect each centerline at two points. From the two points on one centerline, draw two perpendiculars to the other centerline.
4	From the two points on the other centerline, draw two perpendiculars to the first centerline.
5	From the intersection of the four perpendiculars, draw four circular arcs.
6	Darken all outlines.

Oblique Projections, Continued

Circles, arcs, and ellipses (Continued)

Figure 6-7 illustrates the procedure for drawing the four-center method in oblique projection.

**Figure 6-7.**—The ellipse by the four-center method of construction in oblique projection.

Oblique Projections, Continued

**Circles, arcs,
and ellipses
(Continued)**

If you are drawing circles, arcs, or ellipses in an oblique cabinet projection, remember that the receding axis is reduced and you must reduce all measurements along the receding axis by the same scale.

Figure 6-8 shows a circle drawn in a cabinet projection.
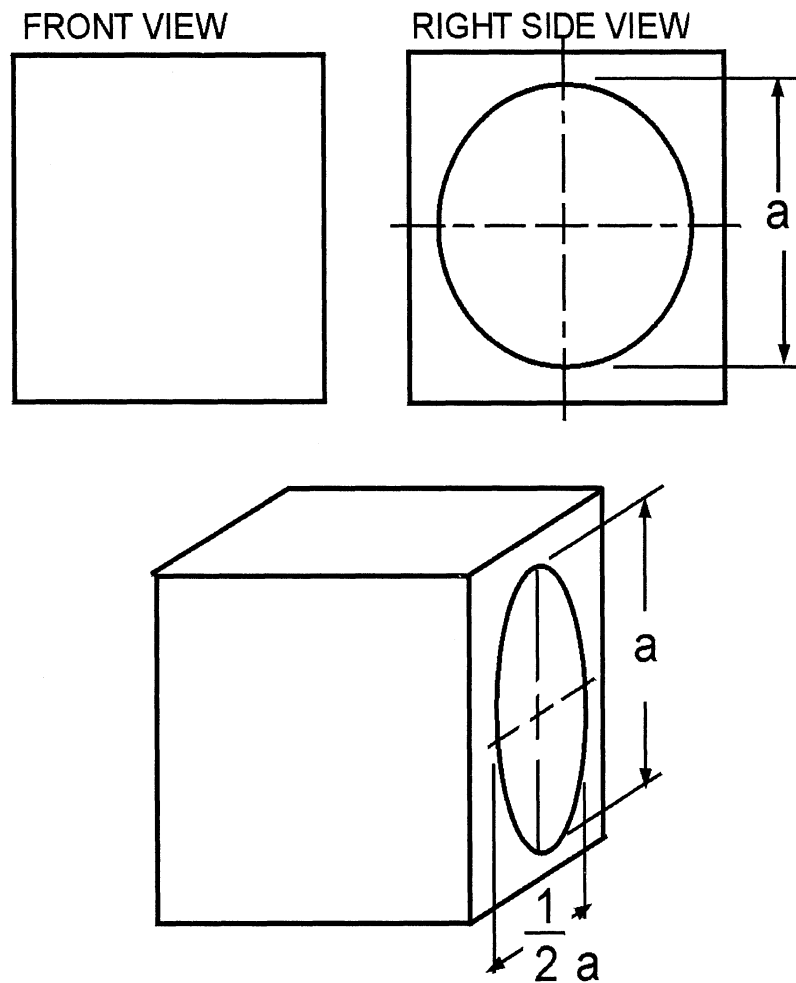
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**Figure 6-8.**—A circle in a cabinet projection.

Oblique Projections, Continued

Offset measurements

Offset measurements are measurements or locations that are parallel to certain edges on the main surface of the object and remain parallel to the same edges after projecting to another view. When an object is drawn as a cavalier projection, all offset measurements may be drawn full scale. If the object is drawn as a cabinet projection where the receding axis is drawn in reduced scale, measurements parallel to the receding axis must be drawn to the same reduced scale.

Figure 6-9 shows an object with offset measurements.
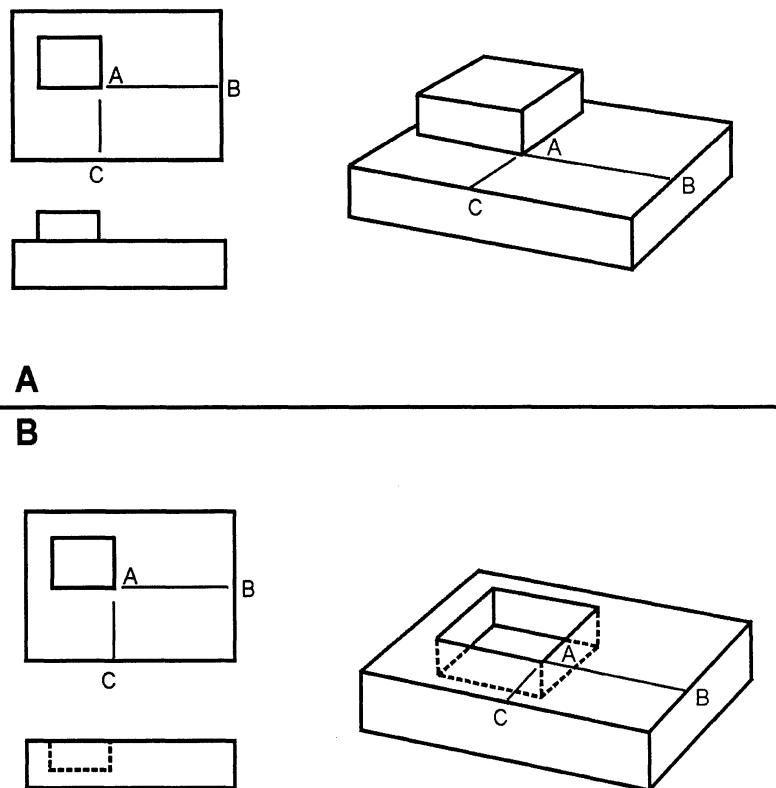
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Figure 6-9.—Offset measurements: A. Raised features, and B. Recessed features.
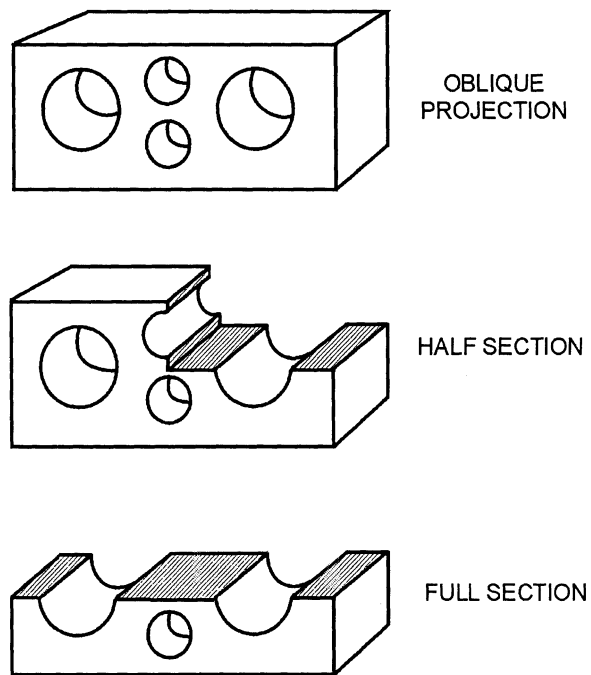
Oblique Projections, Continued

Angles   When an angle of a specific degree lies in a receding plane, you must covert the angle into linear measurements before drawing the angle in oblique projection. Remember that in a cabinet projection, you must reduce all receding dimensions by the same reduced scale.

Sections   Sections in oblique projections are often used to show interior or hidden shapes. Oblique half sections where you remove only a quarter of the object is the most common section used because it shows so much more of the interior surface. Oblique full sections where the plane of intersection passes completely through the object are seldom used. You may use all types of sectional views in an oblique projection.

Figure 6-10 shows a half and full section of an oblique projection.

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Figure 6-10.—An oblique projection with a half
section and full section removed.

Continued on next page

Oblique Projections, Continued

Oblique dimensioning

All dimension lines, extension lines, and arrowheads must lie in the planes of the object to which they apply. Place dimensions outside the object outline except when it helps to clarify. Align dimensions and notes shown with leaders to the bottom of the drawing. Notes without leaders should also be aligned with the bottom of the drawing. There are two systems to indicate dimensions on drawings; the aligned dimension and the unidirectional dimension systems. Select one system of dimensioning to use throughout the drawing. You may show dimensions with either whole numbers and fractions, decimals, or metric units of measure.

ALIGNED DIMENSIONS: Drawings made with aligned dimensions have all figures and notes aligned with a dimension line so that all read from the sides or edges of the drawing. Aligned dimensions are sometimes referred to as pictorial dimensions.

UNIDIRECTIONAL DIMENSIONS: In the unidirectional dimension system, all dimension figures and notes are lettered horizontally and are read from the bottom of the drawing. The unidirectional dimension system is preferred over the aligned system because it is easier to read and understand.

Figure 6-11 are examples of both the aligned and unidirectional dimensioning systems.
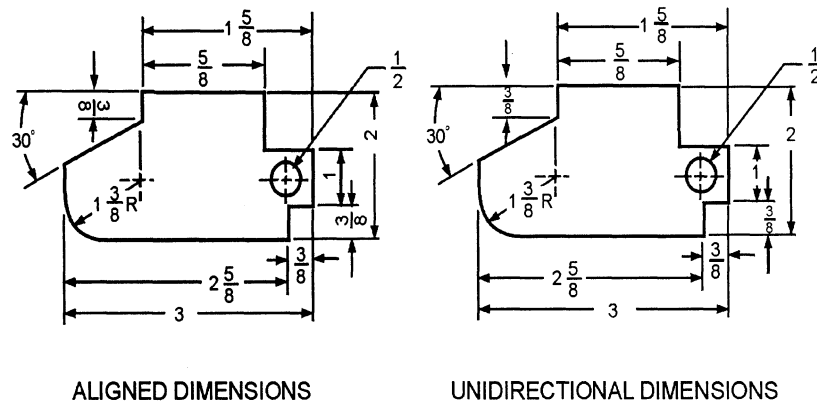
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Figure 6-11.—Dimensioning.
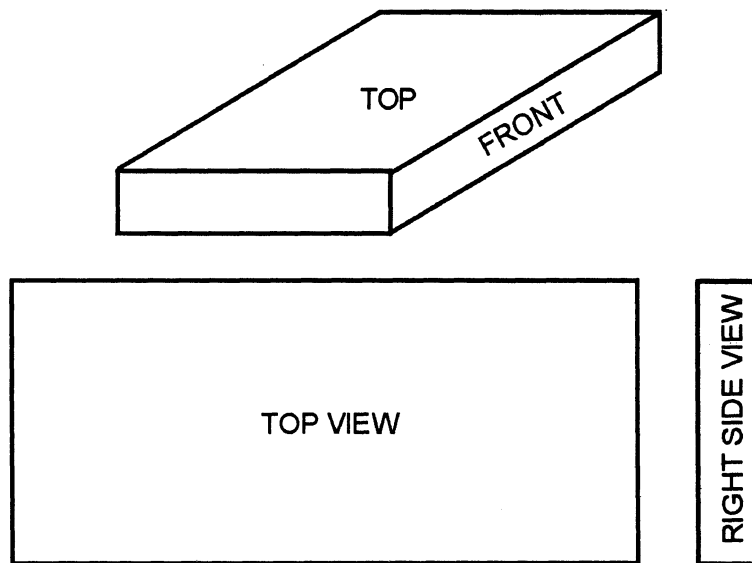
Orthographic Projections

Introduction   The second major classification of parallel projections is orthographic projections.

Orthographic projections   Orthographic projections are drawings where the projectors originating from the observer or station point remain parallel to each other and perpendicular to the plane of projection. For accurate and scientifically correct presentations of objects, piping diagrams, machine, structural, architectural drawings, and furniture design that can be sufficiently understood and replicated by a craftsperson, use a form of orthographic projection. Orthographic projections are commonly referred to as *blueprints* because the method of reproduction, usually by the diazo process, renders the image with a blue line. Orthographic projections are further subdivided into axonometric projections and multiview projections.

Figure 6-12 shows an example of an orthographic projection.
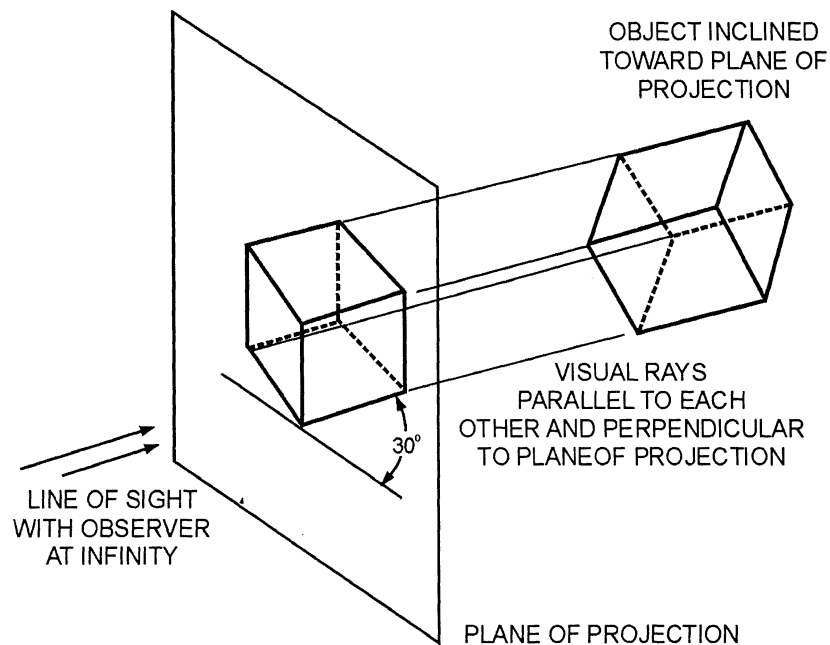

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Figure 6-12.—An orthographic projection.

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Orthographic Projections, Continued

Axonometric projections

In axonometric projections, the observer is located at infinity and the visual rays are parallel to each other and perpendicular to the plane of projection. A key feature of axonometric projections is that the object is inclined toward the plane of projection showing all three surfaces in one view. Since the principal edges and surfaces of the object are inclined toward the plane of projection, the length of the lines, sizes of the angles, and proportions of the object varies according to the amount of angle between the object and the plane of projection. The greater the angle to the plane of projection, the greater the amount of required foreshortening. The three edges that intersect nearest the location of the observer are known as the *axonometric axes (O).* Axonometric projections are further classified as isometric projections, dimetric projections, and trimetric projections.

Figure 6-13 shows an axonometric projection.

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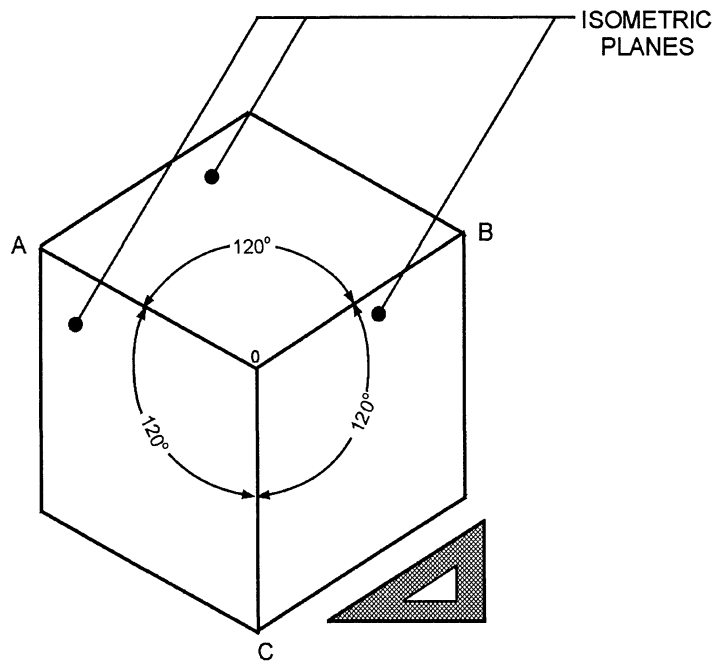**Figure 6-13.**—An axonometric projection.

Orthographic Projections, Continued

Isometric projections

The term *isometric* means equal measure. When principal edges or axes make equal angles with the plane of projection and are equally foreshortened, the result is an isometric projection. Because all angles and lengths are equal, you can used the same scale for the entire layout. The three edges that intersect nearest the location of the observer are known as the *isometric axes* (O) and are 120° apart. The three surfaces shown are referred to as *isometric planes.* Lines parallel to the isometric axes are called *isometric lines.* Lines not parallel to the isometric axes are called *nonisometric lines.* You can generally draw isometric projections without additional auxiliary or revolved views. Most exploded views use isometric projection. Isometric axes and isometric lines are easily constructed with a 30°/60° triangle. Isometric projection is the most frequently used type of axonometric projection.

Figure 6-14 is a cube in isometric projection.

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Figure 6-14.—An isometric projection of a cube.

Orthographic Projections, Continued

Isometric scale   An isometric scale measures foreshortened lines with uniform accuracy. Drawings made using an isometric scale create isometric projections by rendering the object exactly as seen on the plane of projection.   You can make an isometric scale on paper or cardboard to aid you in laying out measurements. All distances in an isometric scale are 2/3 times true length or approximately 80 percent of true size.

To make an isometric scale, use this table:

Step	Action
1	Along a horizontal line, mark off equal increments with any standard scale (figure 6-15, view A).
2	Using a 45° triangle, lay off lines from each of the increments.
3	Using a 45° and a 30°/60° triangles, form a 75° angle with the horizontal and lay off a line intersecting the diagonal lines.
4	Align a piece of paper, acetate, or cardboard, with the 75° line indicating equal increments. These increments form the isometric scale.

Orthographic Projections, Continued

Isometric scale
(Continued)

Figure 6-15 shows how to construct an isometric scale.

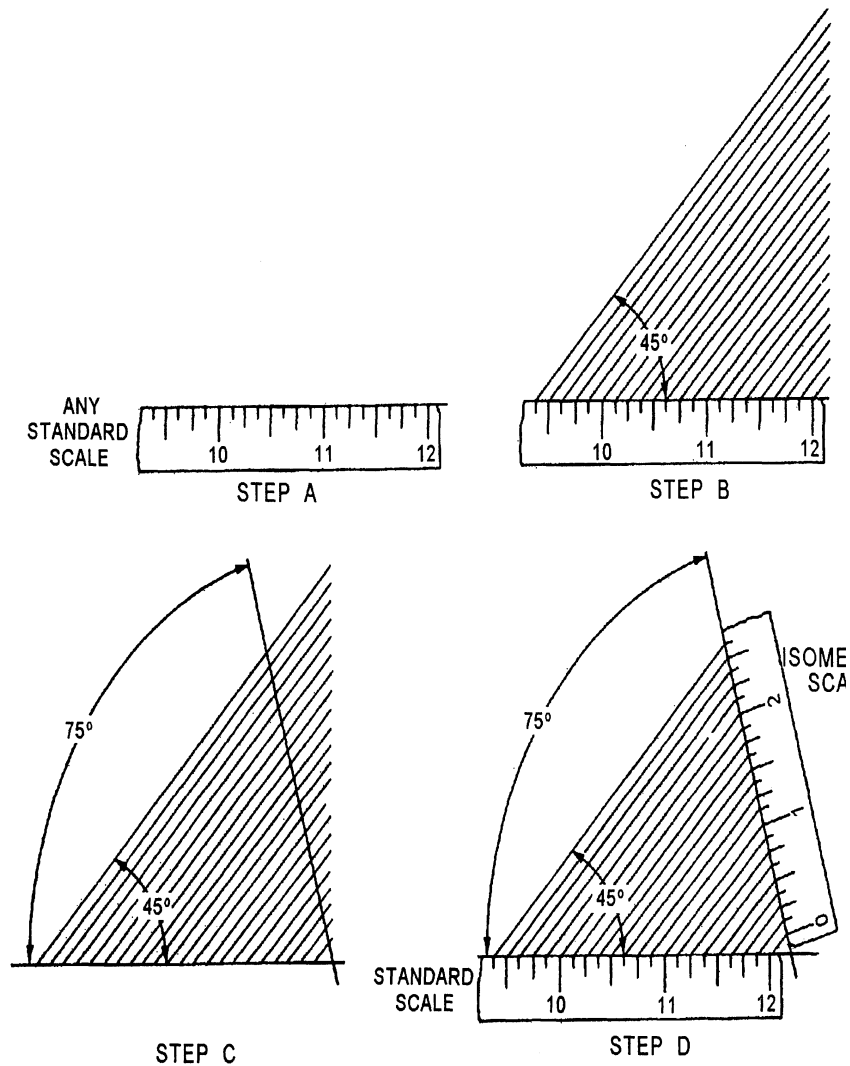Figure 6-15.—Constructing an isometric scale.

6-19

Orthographic Projections, Continued

Isometric drawing

Isometric drawings are drawn using an ordinary scale (not an isometric scale) to lay out measurements. Images in isometric drawings are about 25 percent larger than if rendered as an isometric projection using an isometric scale. Proportion between the projection and drawing is the same. Pictorially, an isometric projection and an isometric drawing appear the same. However, a projection is foreshortened and the drawing is full scale, making it easier to create isometric drawings.

Isometric drawing practices

Begin an isometric drawing by locating the isometric axes. All remaining measurements are made parallel to the isometric axes. You cannot set off any measurements along diagonal or nonisometric lines. Use offset or coordinate measurements to lay out inclined or oblique surfaces or edges.

Position of the isometric axes

The position of the isometric axes depends on the position the object is normally viewed. You may position the isometric axes in any desired location so long as there remains 120° between the axes. Place the long axis horizontally for the best effect in drawing long objects.

Figure 6-16 shows how changing the position of the isometric axes changes the object view.
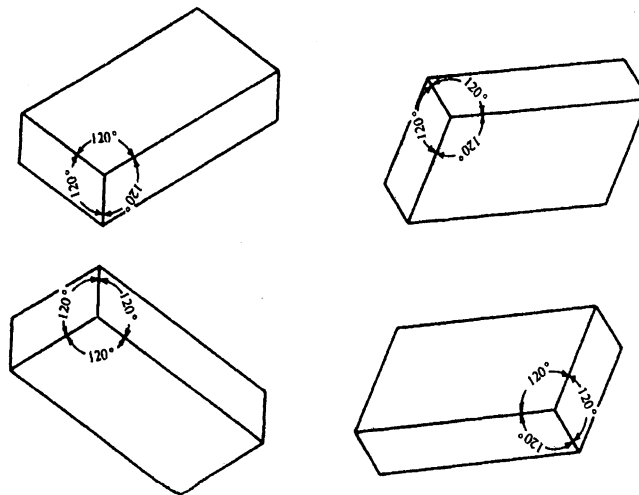
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Figure 6-16.—Changing isometric axes.

Orthographic Projections, Continued

Circles, arcs, and ellipses

Circles, arcs, and ellipses do not appear in true size or shape in an isometric drawing or projection because all surfaces of the projected object are angled toward the plane of projection. To draw circles, arcs, and ellipses in isometric drawings and projections, you must use the offset measurement or four-center method. Make sure to draw enough points to accurately fix the path of the curve. The more points plotted, the greater the accuracy. Once you plot the points, lightly freehand sketch the curve and darken it with the aid of an irregular or french curve.

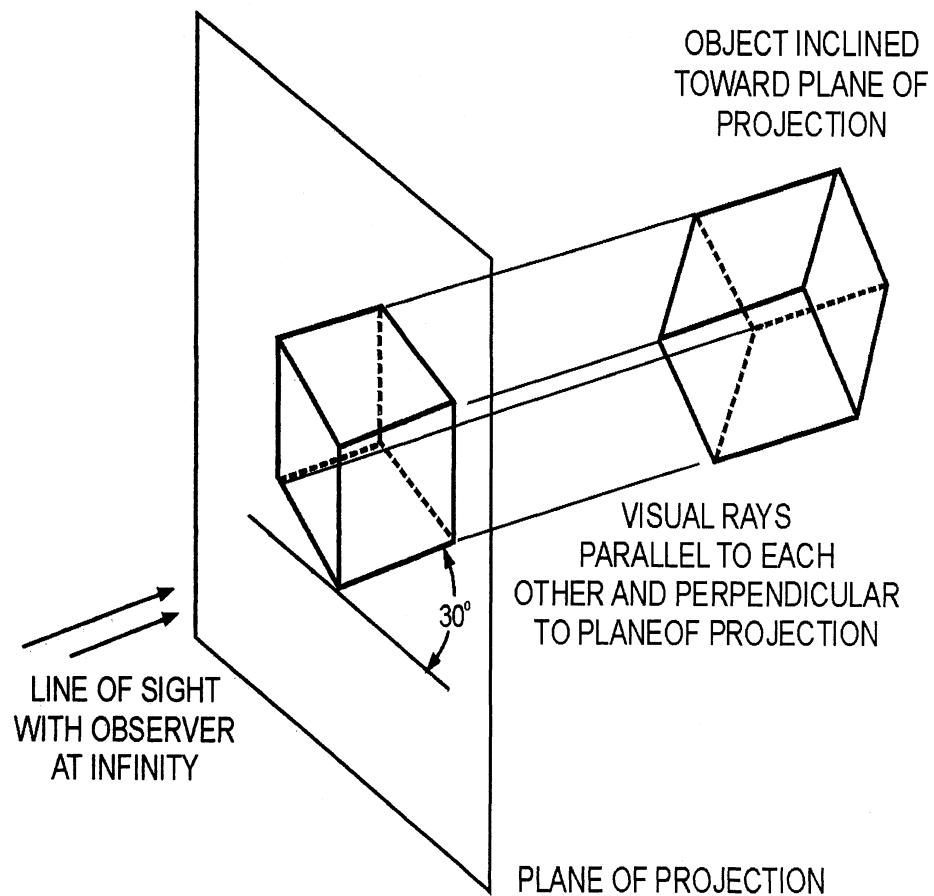To draw circles, arcs, or ellipses by plotting a series of points, use this table:

Step	Action
1	Draw randomly spaced parallel lines across a circle projected in true size and shape on the plane of projection. To increase accuracy, plot more points using more parallel lines.
2	Transfer these lines from the circle to the isometric drawing or projection with a pair of dividers. To locate points in objects with some width, vertically extend the points a distance equal to the width of the object. Some of these points will appear as hidden points and lines.
3	Draw the final ellipse freehand and darken it with an irregular or french curve.

Orthographic Projections, Continued

Circles, arcs, and ellipses (Continued)

Figure 6-17 shows the construction of an ellipse in an isometric drawing.

OBJECT INCLINED TOWARD PLANE OF PROJECTION

VISUAL RAYS PARALLEL TO EACH OTHER AND PERPENDICULAR TO PLANE OF PROJECTION

30°

LINE OF SIGHT WITH OBSERVER AT INFINITY

PLANE OF PROJECTION

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Figure 6-17.—Constructing an ellipse in isometric.

Circles, arcs, and ellipses (Continued)

Ellipses have two axes, a *major axis* (long) and a *minor axis* (short). When the horizontal and vertical centerlines of a circle drawn parallel to the plane of projection is drawn in isometric and each has parallel tangents, they become *conjugate diameters* representing the major and minor axes, respectively. The two diameters of an ellipse are conjugate when each is parallel to the tangents at the ends of the other. One of a given pair of given conjugate diameters is, as a rule, not perpendicular to the other. In general, here are three rules to remember when drawing ellipses in isometric, (1) the major axis of an ellipse is equal to the diameter of the circle, (2) the major axis of the ellipse is always at right angles to the centerline of the circle, and (3) the minor axis is at right angles to the major axis, which coincides with the centerline of the circle. 'Another way of drawing ellipses in isometric is to use an ellipse template. Ellipse templates are available in many different degrees with the major and minor axes marked on the template. Base your selection of the appropriate ellipse on the location and degree of the axes.

Figure 6-18 shows the relationship of the conjugate diameters of a circle to the major and minor axes of an ellipse.
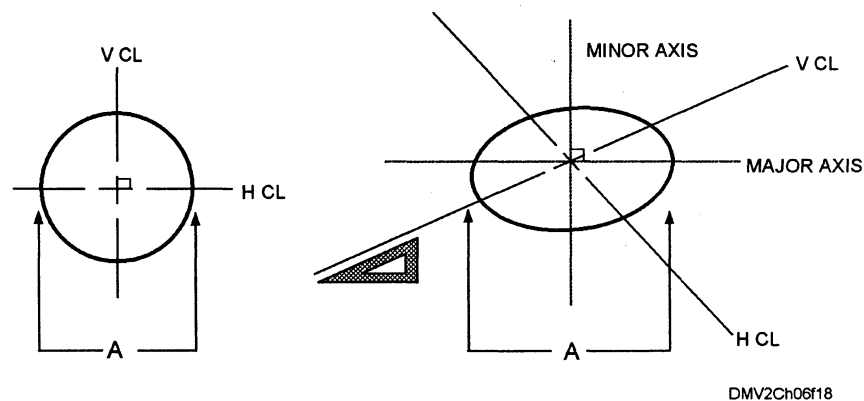

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Figure 6-18.—Major and minor axes.

Offset measurements

Offset measurements are measurements used to locate features or edges with respect to the features and edges on the main surface of the object. Feature and edges parallel to edges of the main surface remain parallel in isometric drawings.

Orthographic Projections, Continued

Angles   Angles project in true size only when the plane of the angle is parallel to the plane of projection. Since the surfaces of an object are inclined toward the plane of projection, most angles will not project in true size. An angle may project larger or smaller than true size depending on its position to the plane of projection. Convert angular measurements into linear measurements before laying them out along isometric lines. You may also use an isometric protractor.

Sections   You may use all types of sectional views in isometric drawings and projections. Half sections are used most often because only a quarter of the object is removed, showing the relationship between the interior and exterior surfaces. When drawing a half section in isometric, draw the entire object first, then remove the half section. When drawing a full section where the cutting plane passes completely through the object in an isometric drawing, draw the cutting plane first, then draw the portion of the drawing behind the cutting plane.
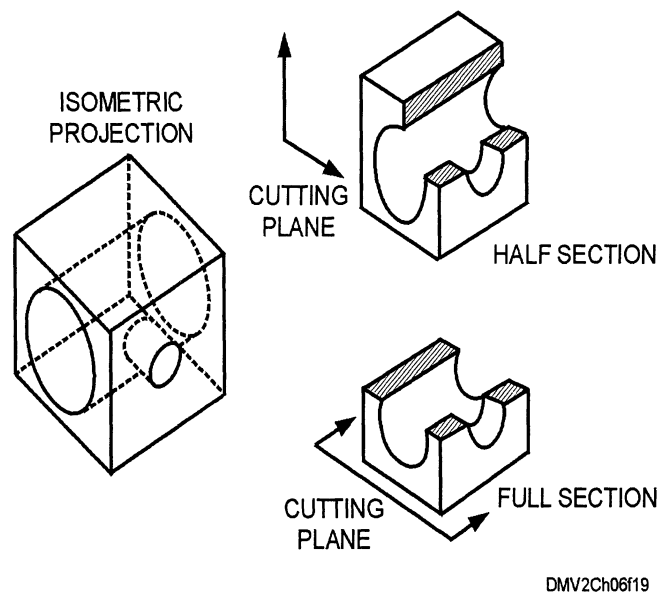
Figure 6-19 shows a half and full section in isometric.

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Figure 6-19.—A half and full section in isometric.

Orthographic Projections, Continued

Isometric dimensioning

Isometric dimensions are similar to dimensions in other types of projections. All dimension lines, extension lines, and arrowheads must lie in the planes of the object to which they apply. Place dimensions outside the object outline. Align dimensions and notes shown with leaders to the bottom of the drawing. Notes without leaders should also be aligned with the bottom of the drawing. You may use the aligned or unidirectional system of dimensioning. Select one method of dimensioning and use whole and fractional numbers, decimals, or metric units of measure. Remain consistent throughout the drawing.
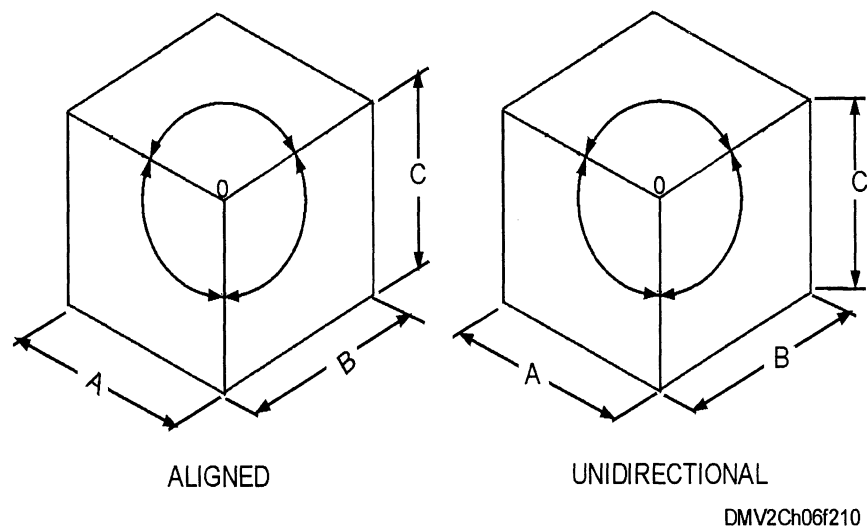
Figure 6-20 shows isometric dimensioning.

ALIGNED   UNIDIRECTIONAL

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Figure 6-20.—Isometric dimensioning.
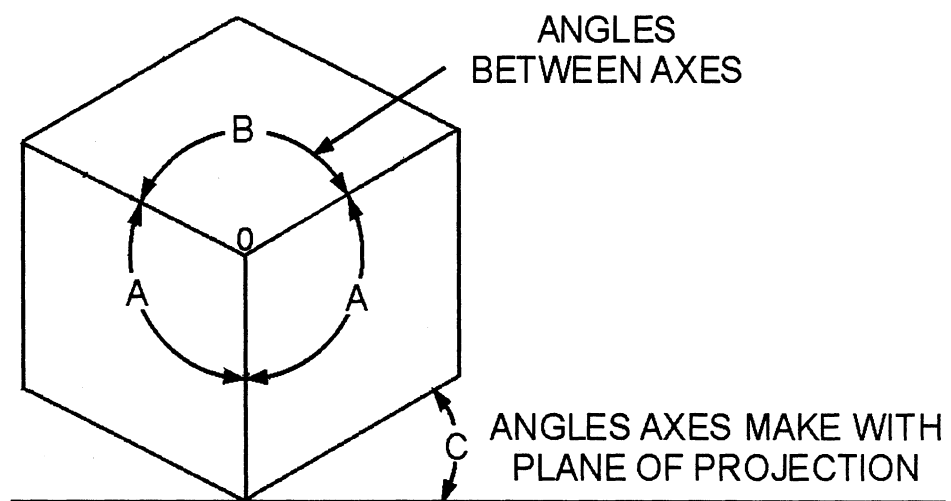
Orthographic Projections, Continued

Dimetric projections

A dimetric projection is an axonometric projection where two of an objects axes make equal angles with the plane of projection and the third angle is larger or smaller than the other two. You use one scale for the two equal axes and change scale to foreshorten the third axis in a different ratio. Do not confuse the angles between the projection of the axes and the angle the axes make with the plane of projection. Dimetric projections are used less often than isometric projections.

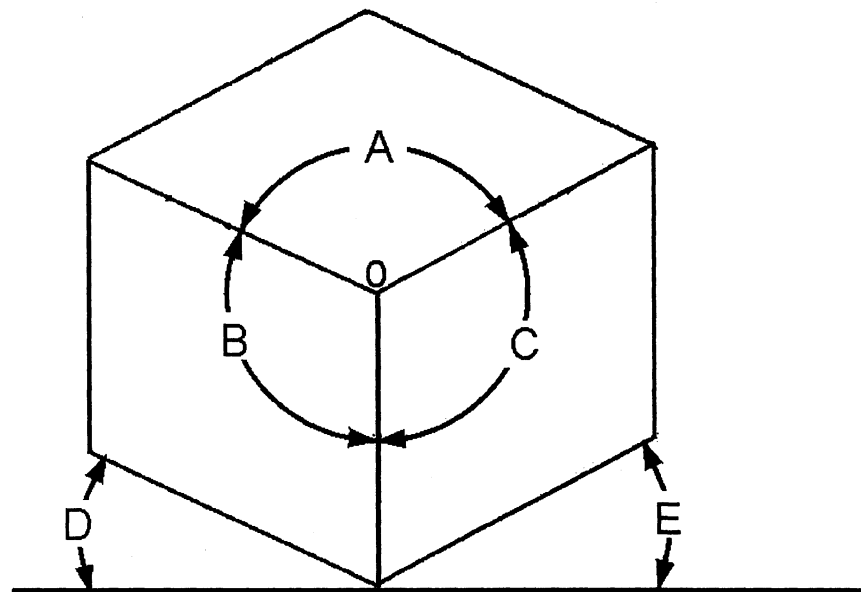Figure 6-21 shows an example of dimetric projections.

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Figure 6-21.—A dimetric projection.

Orthographic projections, Continued

Trimetric projections

A trimetric projection is an axonometric projection where no two axes form equal angles with the plane of projection. Each of the three axes and the lines parallel to them have different ratios for foreshortening. The object is projected so that no axis forms an angle less than 90° and three different trimetric scales must be used to lay out measurements along the axes.

Figure 6-22 is an example of a trimetric projection.

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Figure 6-22.—A trimetric projection.

Orthographic Projections, Continued

Multiview projections

Multiview projections are the second major subdivision of orthographic projections.

Principal views

There are six principal views in a multiview orthographic projection. These are the front, back, top, bottom, and left- and right-side views. Of these views or planes, three are referred to as primary planes of projection (vertical, horizontal, and profile). Most objects are adequately represented by the three primary planes.

Angles of projection

The primary planes intersect each other at right angles. The angles between the horizontal and vertical planes are described as first, second, third, and fourth angles of projection. In theory, you can place an object in any of these angles of projection and draw or project its image onto the projection planes, which in turn could be rotated onto the plane of your drawing paper. Only first- and third-angle projection have a practical application today.

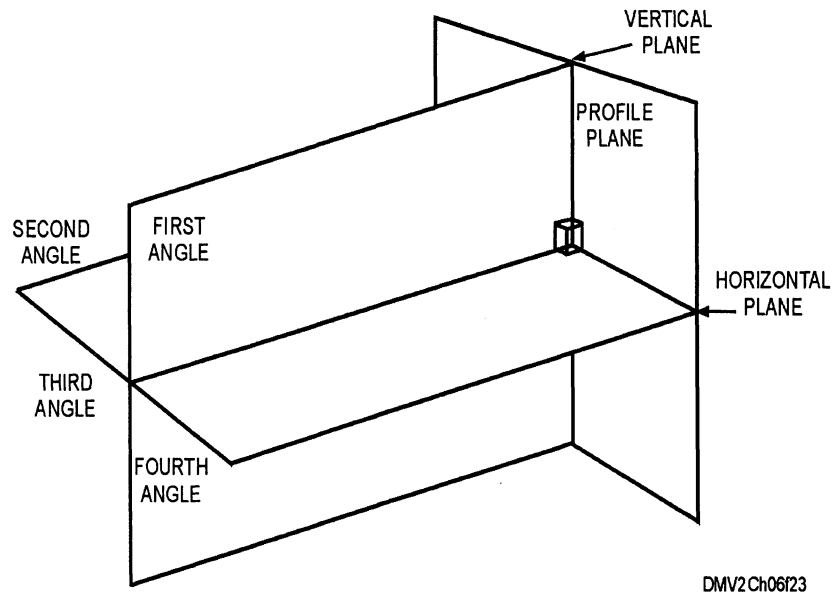Figure 6-23 shows the angles of projection in a multiview projection.

Figure 6-23.—Angles of projection in multiview projections.

Orthographic Projections, Continued

First-angle projections

First-angle projection places the object on the profile plane with the vertical plane on the left and the horizontal plane on the bottom and is used throughout Europe. This position locates the top view below the front view, the right-side view on the left side of the front view, and the bottom view above the front view. Because the positioning of the views initially seems illogical, first-angle projections is not taught or practiced in the United States.

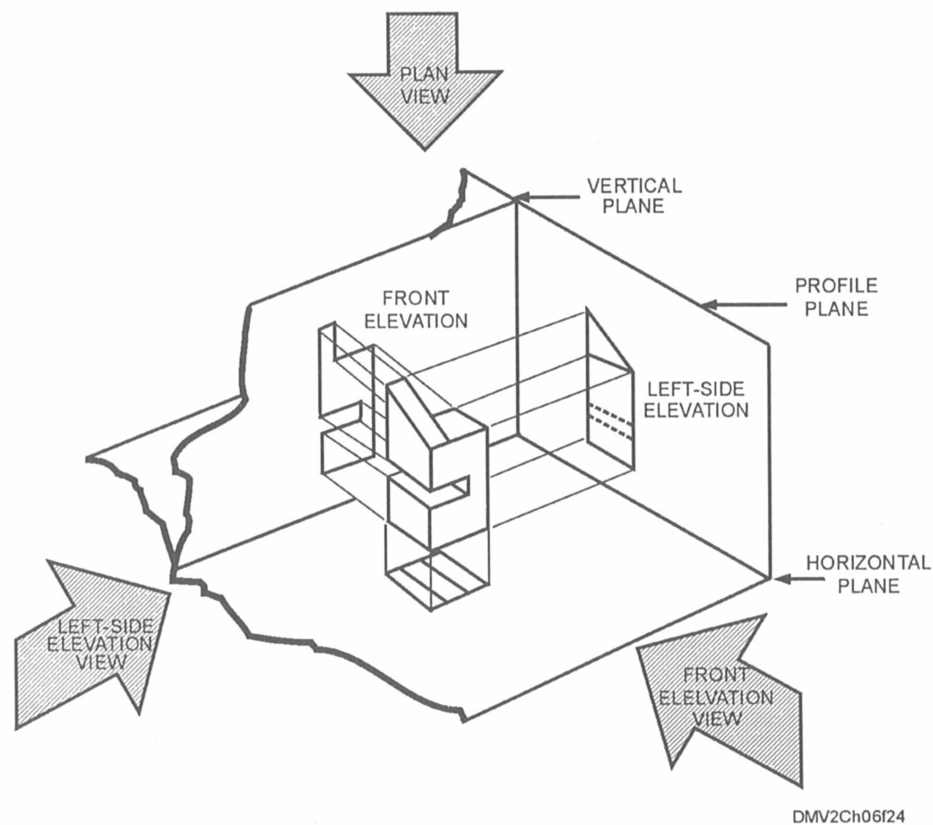Figure 6-24 shows how the principal views are hinged in first-angle projection.

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Figure 6-24.—Principal views in first-angle projection.
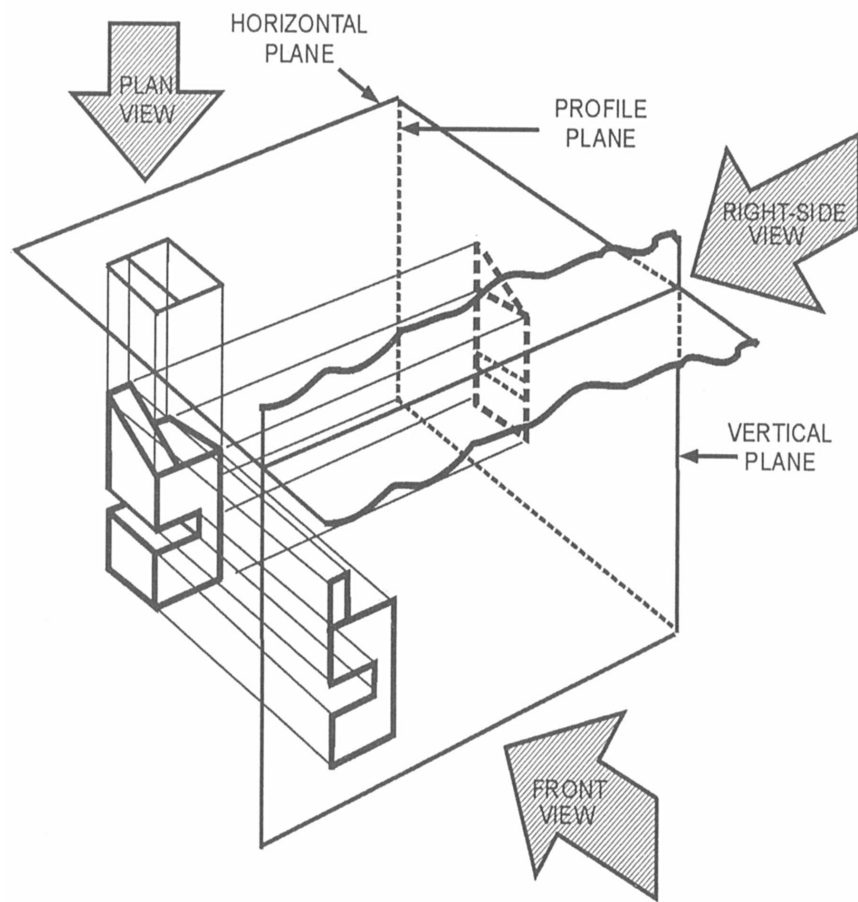
Orthographic Projections, Continued

Third-angle projections

Third-angle projection places the object with the front view projected onto the vertical plane, the top view onto the horizontal plane, and the right-side view onto the profile plane. The arrangement of the three views on paper is logically sequenced. Since the late 1800s, third-angle projection has been the American standard in drafting practice.

Figure 6-25 shows third-angle projection.

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Figure 6-25.—Principal views in third-angle projection.

Orthographic Projections, Continued

Position of the principal views

When you see all six planes of projection with their respective images in space, they form a transparent, box-like structure in which the object itself appears suspended in air. In third-angle projection, as the box opens, all views rotate toward the observer as though they were hinged. The front view always lies in the plane of the drawing surface and does not rotate. Each view has two of the three common space dimensions of height, length, and depth and adjacent views supply the missing dimension. The relative positions of the six principal views and their relationship to each other are logically arranged on a drawing surface.

Figure 6-26 shows the revolution and eventual position of the six principal views in third-angle projection.
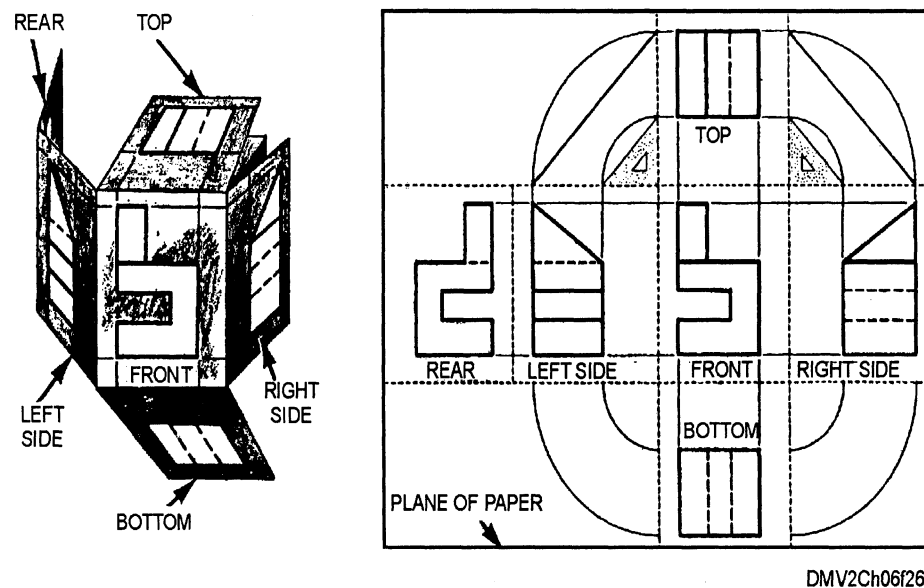

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Figure 6-26.—Revolution and position of the six principal views in third-angle projection.

Orthographic Projections, Continued

Miter lines   Miter lines are a convenient method for laying out a third view when drawing
the primary planes or views on paper. Any horizontal movement of the miter
line to the left or right controls the distance between the views to allow space
for dimensioning.

To use a miter line to draw a third view, use this table:

Step	Action
1	Place a horizontal and vertical centerline between the two views at any convenient distance (lines AB and CD).
2	Draw a miter line to the intersection of the horizontal and vertical centerlines (figure 6-27, view A).
3	Lightly draw projectors from the top view to the miter line (figure 6-27, view B).
4	Lightly draw vertical projectors from the points of intersection of the miter line and horizontal projectors.
5	Using the front view, draw horizontal projectors to the vertical projectors. The result is the outline and placement of the third view (figure 6-27, view D).

**Miter lines
(Continued)**

Figure 6-27 shows how to use a miter line.
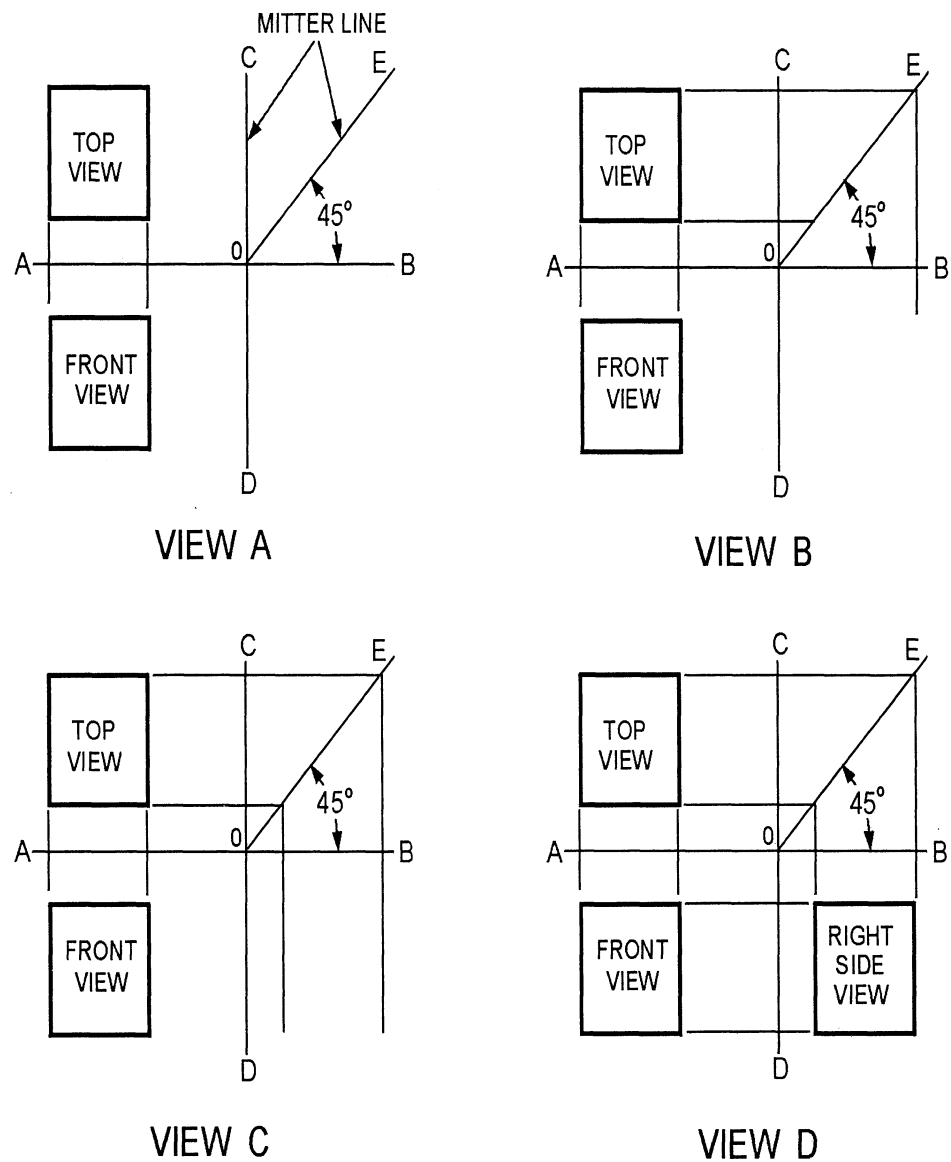
Figure 6-27.—Using a miter line.
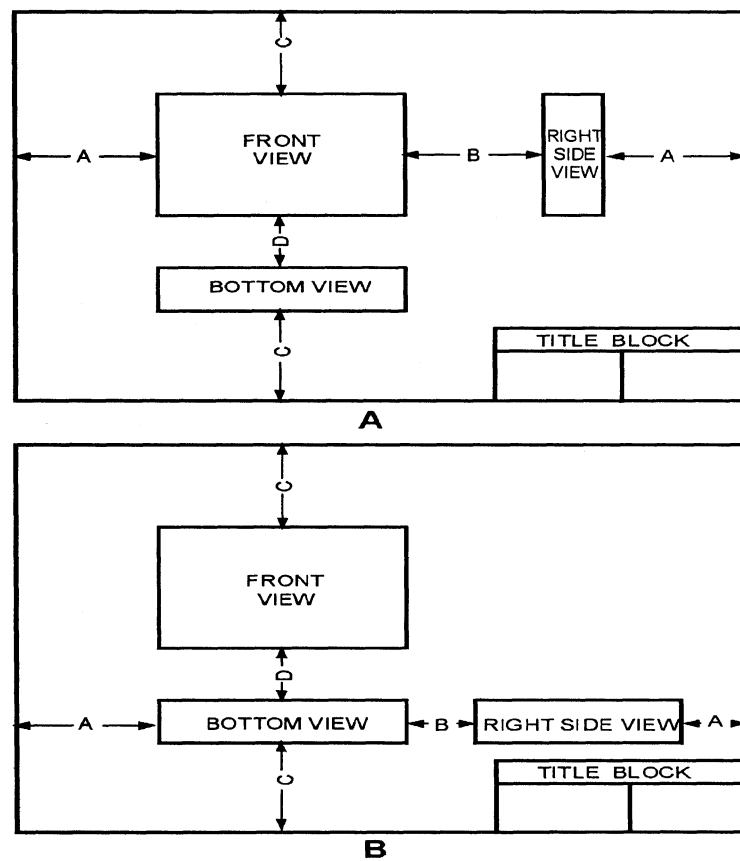
Orthographic Projections, Continued

Proper spacing of views

Space views on your drawings to give the appearance of a balanced drawing. In general, the top and bottom margins are equal and the left and right margins are equal. Sometimes the spacing of the views is technically correct but the image interferes with the placement of the title block or appears off balance. If the object allows arbitrary choice with regard to the designation of views, you can improve the spacing by changing the designation. Spacing views in a drawing of a circular object is like spacing letters -you must try to equalize the areas of space around and between the views.

Figure 6-28 shows technically correct spacing and improved spacing for a three-view drawing of a rectangle.

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Figure 6-28.—The spacing of views: A. Technically correct, and B. Visually improved.

Orthographic Projections, Continued

Analyzing a multiview projection

In third-angle projection, the plane of projection is always presumed to be between the object and the observer regardless of which view you are considering. Each view of the surface of an object is a view of that surface as it would appear to an observer looking directly at it. You should be able to determine what each line in a particular view represents.

Choosing the necessary views

A multiview projection should contain only as many views required to describe the object fully. Most objects can be described in two or three views. One-view drawings are objects that can be completely defined by that view. Features such as thickness or length is listed as a dimension or note. Many objects have no definite top or bottom. With objects of this kind, select a surface and call it according to convenience. When eliminating views, here are four rules to remember, (1) show an object in the position it customarily occupies, (2) a top view is preferable to a bottom view, (3) a right-side view is preferable to a left-side view, and (4) a view with a visible line is preferable to a view with the same line shown as a hidden line.

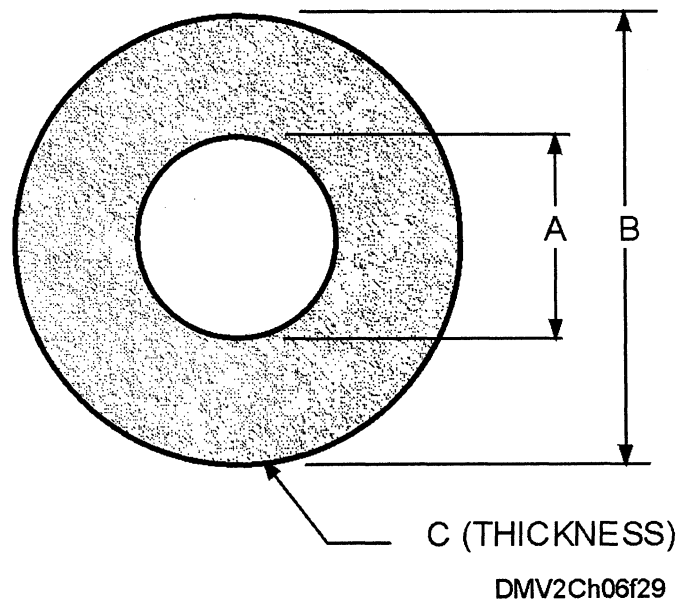Figure 6-29 show a one-view drawing of a washer.

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Figure 6-29.—A one-view drawing.
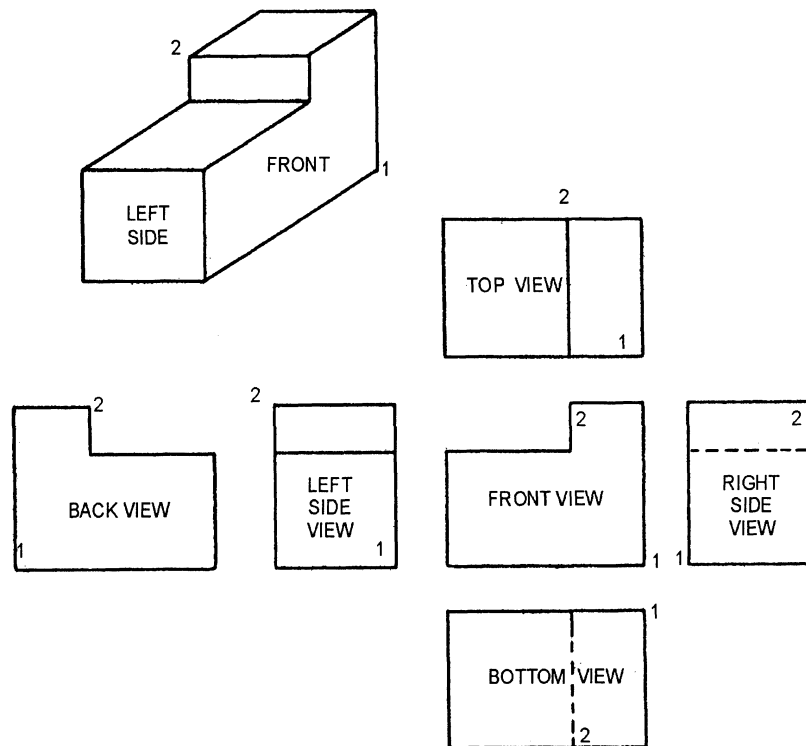
Orthographic Projections, Continued

Corner point numbering

To help understand the view of an object, you may assign a number to each of the corners. A corner point may be hidden or visible in a particular view of the object. Hidden corner points are numbered inside the object's outline; visible corner points are numbered outside the outline.

Figure 6-30 shows an object with a hidden and visible numbered corner point.

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**Figure 6-30.**—Corner point numbering.

Orthographic Projections, Continued

Normal and oblique lines

A normal line in a multiview projection is parallel to two of the planes of 'projection and perpendicular to the third. A line parallel to a plane of projection appears in true length depending on the scale of the drawing. A line perpendicular to a plane of projection appears on that plane as a point. A line perpendicular to one plane of projection must be parallel to the other two, but a line parallel to one plane of projection may be oblique to one or both of the others. This type of oblique line appears in true length in a view on the plane of projection to which it is parallel but appears foreshortened in all regular views of the object.

Figure 6-31 is a pictorial drawing of a block in the upper-left corner. Placing the front face parallel to the vertical plane in a multiview projection places the bottom face parallel to the horizontal plane and right-side face parallel to the profile plane. Line AB is parallel to the vertical plane but oblique to both the horizontal and the profile planes. Only in the front and back views is line AB shown in true length. In all other views AB is foreshortened.
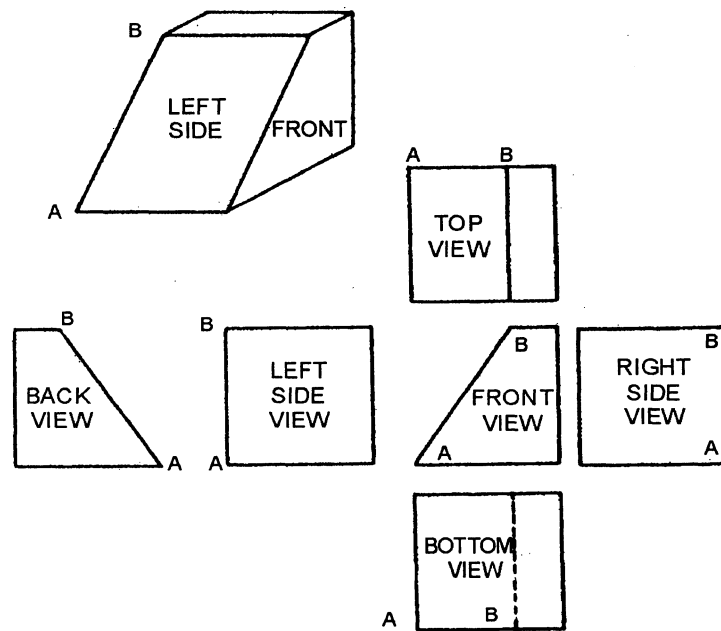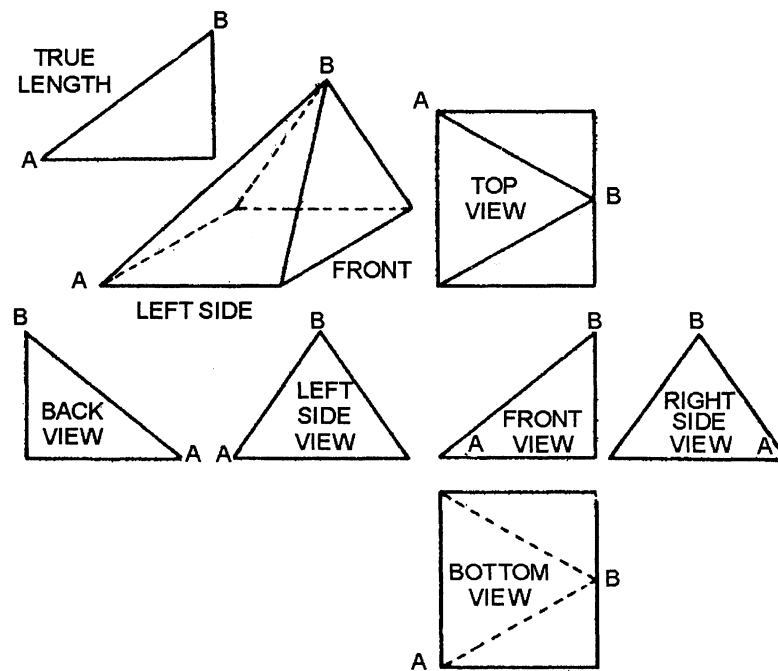

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Figure 6-31.—Line AB in true length on the front and back view.

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Orthographic Projections, Continued

Normal and oblique lines (Continued)

Figure 6-32 shows a pictorial drawing of a triangular object in the upper-left corner. The right side is presumed parallel to the profile plane of projection, the bottom view parallel to the horizontal plane, and the front view parallel to the vertical plane. The line AB is oblique to all three planes. The true length of AB is shown in the small triangle to the left of the single-view projection. It is the length of the hypotenuse of a triangle with the altitude equal to the length of AB as it appears in the top view of the multiview projection. AB is foreshortened in all of the orthographic views.

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Figure 6-32.—Oblique lines foreshortened in all orthographic views.

Circles, arcs, and ellipses

In multiview projections, a circle on surfaces parallel to the plane of projection appears as a circle. A circle on a surface that is oblique to the plane of projection appears as an ellipse.

Parallel Practices

Introduction

Drawing practices for parallel projections are more standardized than for perspective projections. There is very little latitude for creative interpretation of an object and more use of drawing and drafting instruments. Parallel projections are working drawings or blueprints.

Mechanical construction

Use a scale, straightedge, triangles, and templates to mechanically construct accurate parallel projections.

Scale

Select a scale or ratio to represent the object on paper. Modify each measurement you make with the selected scale. Make note of the scale you select to enter in the appropriate space in the title block of the drawing.

Layout

All elements combined in a parallel projection drawing should present a balanced appearance. If you elect to draw your projection on standard drawing paper with preprinted information blocks and borders, consider the placement of views and the proximity of the information blocks. Make sure the drawing doesn't overcrowd or interfere with information blocks. Do not arbitrarily alter the relationship of adjacent views on the paper because you incorrectly spaced the views.

Measurements

All lines parallel to the picture plane project in true size or full scale. All lines perpendicular to the plane of projection project as a point. Oblique or inclined lines are foreshortened. Use offset measurements to locate surface characteristic that share common edges.

Circles, arcs, and ellipses

Circles, arcs, and ellipses parallel to the plane of projection appear in true size and shape. Circles not parallel to the plane of projection appear as ellipses. Use the system of plotted points or circumscribed circle method of projecting circles, arcs, and ellipses on surfaces not parallel to the plane of projection since these curves have no direct transferable measurements.

Reflections, shadows, and shade

Parallel projections generally do not contain reflections, shadows, and shading since this would interfere with any textural implications made by crosshatching, stipple, or other pattern.

Parallel Practices, Continued

Partial views   Use a partial view if necessary to clarify the description of an object. Use a break line or the contour of the object itself to define the limitations of the partial view. Do not place break lines too near a visible or hidden line. For symmetrical objects, consider using a sectional view.

Sectional views   You may use any type of sectional view in a multiview projection so long as its purpose is to clarify the features of an object. A cutting-plane line indicates the part being viewed with the arrowhead showing the direction of sight.

Revolved or removed sections   You should use removed or revolved views on multiview projections to clarify an objects profile. Removed sections may be partially removed and rotated toward the plane of projection or they may be a separate revolution of the entire object aligned with the primary view as in an aligned section. Removed views are indicated by a viewing-plane line with arrowheads indicating the direction of sight. The viewing-plane shows a portion of the object as it would appear if removed from the object.

Angles   In multiview projections, angles on the surface of an object that is parallel to the plane of projection appear in true size and shape. Angles on surfaces not parallel to the plane of projection appear foreshortened. Convert angle into linear measurements before drawing.

Dimensioning   All dimension lines, extension lines, and arrowheads must lie in the planes of the object to which they apply. Place dimensions outside the object outline except when it helps to clarify. Align dimensions and notes shown with leaders to the bottom of the drawing. Notes without leaders should also be aligned with the bottom of the drawing. You may use either aligned or unidirectional methods of dimensioning. Use either whole numbers and fractions, decimal, or metric units of measure to mark dimensions on a drawing.

Lettering   Lettering on multiview projections is single-stroke gothic. Lettering is vertical in orientation.

Summary

Review

This chapter acquaints you with the various types of parallel projections. There are vast differences between oblique and orthographic projections. Oblique projections, particularly isometric projections are the most widely recognized because of their unique angular relationship to the plane of projection. Orthographic projections are most closely associated with blueprints or working drawings used for all types of construction. The chapter terminates with standard practices for rendering objects in parallel projection.

Comments

The theory and study of parallel projections develop your ability to think or visualize in three dimensions. Parallel projections are methodical, logical, mathematically correct representations of real objects or what could become real objects. Understanding parallel projections increases your ability to understand the mechanical interrelationship between parts from a wheel bearing on your automobile to the component parts of a Rubik's cube.

A suggestion for increasing your understanding of perspective and parallel projections is to look at the projection chart in the beginning of this chapter to get an overall feel for the subject. Select only one block (type of projection) and study it until you understand it. Then, return to an overall study of projections to fully grasp the relationship between the different types of projections.